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(NASA-CR-149868) ENERGY CONSERVATION AND ANALYSIS AND EVALUATION (Keller and Gannon, San Francisco, Calif.) HC A04/MF A01 CSCL 10B

N77-19582

Unclas

G3/44 22586

SECTION A

INTRODUCTION

SECTION A

INTRODUCTION

The energy conservation survey discussed in this report was conducted under Contract NASW-2917 with the National Aeronautics and Space Administration, Washington, D.C.

Objectives

The objectives of the survey were to assemble and make recommendations directed at conserving utilities and reducing the use of energy at the Slidell Computer Complex. Specific items included in the work were:

- Scheduling and controlling the use of gas and electricity.
- Building modifications to reduce energy. requirements
- Replacement of old, inefficient equipment.
- Modifications to control systems.
- Evaluations of economizer cycles in HVAC systems.
- Corrective settings for thermostats, ductstats, and other temperature and pressure control devices.
- Revisions to lighting system to reduce usage. ?
- Revisions to miscellaneous systems to reduce usage. ?
- Possible methods of improving maintenance and operating doctrines for all systems.
- Possible use of an Energy Monitoring and Control System (EMCS) to reduce energy usage, optimize operation, and reduce maintenance.

Basis for Recommendations

The recommendations presented herein have been selected to achieve optimum equipment and system performance, adequate reliability, and capacity to ensure that the complex will be able to fulfill its mission with the minimum usage of energy.

Acknowledgments

The conduct of the survey has been greatly aided by the efforts of the staffs of the various engineer groups concerned and by the personnel of the Slidell Computer Complex.

SECTION B

CONCLUSIONS AND SUMMARY OF RECOMMENDATIONS

SECTION B

CONCLUSIONS AND SUMMARY OF RECOMMENDATIONS

Conclusions

1. Energy costs used in the evaluations have been escalated in accordance with past history tempered by engineering judgment, resulting in annual increases of 25 percent for electricity and 30 percent for natural gas. The cost of energy is, of course, a very serious matter and essential in the cost-effective phase of analyzing the recommendations. Care must be exercised to attempt to balance the effect of possible energy "rationing" or "limited demand" which some expect to be in effect within the next decade.

2. The main building of the Computer Complex was constructed in the early 1960's, with additional increments being added throughout the ensuing years. The Uninterrupted Power Supply Building, completed in 1975, was the most recent addition. The designs and equipment selections were made at a time when energy conservation and costs did not have the present day impact. As a result, revisions to achieve energy savings are difficult to implement.

3. Basically, the potential energy savings presented herein utilize existing systems and equipment to the maximum extent possible, replacing and/or modifying components to achieve increased efficiency.

4. Shedding of electrical loads is considered to be essential in the future operational planning of the complex. In view of the mission of the complex, it is extremely difficult to reduce the electrical loads to any major extent without seriously affecting the computer output.

Any major load shedding plan will have to be established by management and should be considered to be a contingency plan which, hopefully, will never have to be implemented. why [illegible] [illegible] load shedding is [illegible] the [illegible]

5. The increase in workload of the complex, which is expected to continue through 1976, makes an energy reduction plan even more difficult to accomplish. ? why not say "even more important" rather than difficult.

6. An energy control and monitoring system will provide a means of optimizing energy usage, controlling electrical demand, and improving the operational control of critical temperatures and humidities. The system can be used in the event it is necessary to implement a major load shedding program.

7. A well disciplined energy conservation program has been in effect at the complex for the past three years. It is difficult to find any area where a major energy saving can be effected.

8. Possible total savings of 9.483×10^9 Btu/year are indicated out of a total of 49.3×10^9 Btu/year used in calendar year 1975. This is a 19 percent reduction. However, considerable funds will be required to effect the saving. The two largest single items are the improvement in boiler efficiency (2.4×10^9 Btu/year) and the rebalancing and improvements to the air conditioning system (3.9×10^9 Btu/year).

9. The equipment serving the Cafeteria appears to be oversized for the present usage. Examples are refrigeration equipment, the steam kettle, the grill, the steamer, and the steam unit heater. An in-depth review and cost analysis of installed equipment versus present operations is required. Some other method of food service may be beneficial from an energy usage standpoint.

10. Operation and Maintenance (O&M) costs for the individual items of the recommendations were developed in conjunction with site personnel, and material costs were extracted from their records.

ENERGY REDUCTION RECOMMENDATIONS

RECOMMENDATION	BUDGET ESTIMATE	ANNUAL SAVINGS ENERGY $	ANNUAL SAVINGS ENERGY Btu x 10^9	ANNUAL SAVINGS O&M $	PAY BACK (YEARS)	REF. PAGE
HVAC 1 - Use gas fired hot water heater to serve cafeteria	FY76 $ 650	70	.060		4.6	4-2
HVAC 2 - Increase size of condensate return tanks	FY76 $ 1,050	200	.170	4,300	.1	4-2
HVAC 3 - Disconnect and remove steam grid humidifiers serving office areas	FY76 $ 2,200	100	.085	500	3.0	4-2
HVAC 4 - Remove steam unit heater in kitchen	FY76 $ 180	50	.040	50	1.5	4-2
HVAC 5 - Provide load analyzers on air handling units #10 and #11	FY76 $ 5,000	Savings		in	EM1	4-2
HVAC 6 - Provide lockout control so A/C will not operate in office areas with thermostats set at 68°F	FY76 $ 3,600	230	.039	(100)	6.9	4-2
HVAC 7 - Renovate ventilating system in Electrical Switchgear Room	FY76 $ 800	1,180	.200	300	.4	4-3
HVAC 8 - Revise attic ventilation	FY76 $ 350	200	.034	75	1.2	4-3
HVAC 9 - Revise basement duct work to separate computer and office areas	FY76 $ 9,600	800	.515	2,200	2.5	4-3
HVAC 10 - Replace steam-grid humidifiers in computer areas	FY79 $29,000	-	-	1,000	4.5 (HVAC 10 and 11)	4-3
HVAC 11 - Replace the four 37.5 HP steam boilers with hot water boilers	FY79 $51,900	2,832	2.400	5,500		4-4
HVAC 12 - Provide ceiling insulation	FY76 $ 3,300	400	.239	-	4.2	4-4

ENERGY REDUCTION RECOMMENDATIONS (Continued)

RECOMMENDATION	BUDGET ESTIMATE	ANNUAL SAVINGS ENERGY $	ANNUAL SAVINGS ENERGY Btu $\times 10^9$	ANNUAL SAVINGS O&M $	PAY BACK (YEARS)	REF. PAGE
HVAC 13 - Provide in-depth analysis of air conditioning system	N/A	4,550	3.860	-	-	4-8
P-1 - Reset domestic hot water controls	-	30	.025	-	-	4-4
L-1 - Provide additional switches for local lighting control	FY76 $ 9,100	880	.145	500	4.1	4-4
L-2 - Replace incandescent lighting fixtures with fluorescent units	FY76 $ 8,200	840	.143	200	4.4	4-5
E-1 - Provide capacitors	FY76 $ 4,300	500		-	4.5	4-5
EM1 - Provide energy monitoring and control system	FY79 $104,000	6,854	1.528	2,000* (Net)	6.3	4-5
TOTALS		$19,716	9.483	16,125		

* $6,000/year O&M savings minus $4,000/year for maintenance of system.

SECTION 1

GENERAL CONSIDERATIONS

SECTION 1

GENERAL CONSIDERATIONS

Location

The National Aeronautics and Space Administration Slidell Computer Complex (SCC) is located in Slidell, Louisiana, approximately 35 miles northeast of New Orleans.

Description

The complex includes a three-story Computer Operations Building which contains all of the computer equipment on the site. Several smaller support buildings are located south of the main building. An aerial photograph of the site is shown in Figure 1-1.

Mission

The mission of the computer complex is to provide precomputer and computer processing, storage, and distribution of data for the Marshall Space Flight Center, the Earth Resources group, associated contractors in support of the Michoud Assembly Facility, the Mississippi Test Facility, and other authorized users.

Climatic Design Conditions

The outside design conditions for heating and air conditioning systems are:

Heating	33°F Dry Bulb	
Cooling	93°F Dry Bulb	80°F Wet Bulb

The design conditions were substantiated by 10-year weather data furnished to the field team by operating personnel.

Computer Workload

At the time of the survey, the basic computer workload required three shifts per day, five days per week, supplemented by some weekend shifts. Management personnel expect that the workload will increase to a point where additional weekend shifts will be required. Excerpts from the complex's "Workload Projection Reports" for FY76 and FY77 are shown in Table 1-1.

Energy Usage and Cost - 1973 to 1976

Electrical and natural gas usage at the complex for calendar years 1973, 1974, and 1975, together with the first two months of 1976, is shown in Tables 1-2 and 1-3. The data is summarized below.

	1973	1974	1975
Electricity			
Usage	9.91×10^6 kwh	8.99×10^6 kwh	8.49×10^6 kwh
Max. Demand	1,382 kw	1,332 kw	1,359 kw
Cost	$117,874	$137,984	$168,960
Cost/kwh	$ 0.012	$ 0.015	$ 0.02
Natural Gas			
Usage	206,712 ccf	249,939 ccf	203,022 ccf
Cost	$ 10,568	$ 17,114	$ 20,693
Cost/ccf	$ 0.051	$ 0.068	$ 0.102

Over the three-year period, electrical usage decreased approximately 14 percent, but the unit cost increased 67 percent. The usage of natural gas decreased slightly in 1975, compared to 1973, but the unit cost increased 100 percent.

The cost of electrical energy in 1975 was eight times that of natural gas. The energy usage can be compared on a Btu data base as follows:

Electricity	29.0×10^9 Btu
Natural Gas	20.3×10^9 Btu

Conversion from billing data bases utilized the following factors:

1 cu. ft. natural gas	=	1,000 Btu	utility Co uses 1150 ±
1 kwh electricity	=	3,412 Btu	

Twenty-four-hour electrical load curves were developed for the total building load, the electronic load, and the uninterrupted power system inputs. These data are presented in Figures 1-2 and 1-3. Attention is directed to the relatively steady electrical demand for a 24-hour period, with a minimum to maximum variation of approximately 120 kva, or 10 percent.

A&PS

SLIDELL COMPUTER COMPLEX

MARSHALL SPACE FLIGHT CENTER

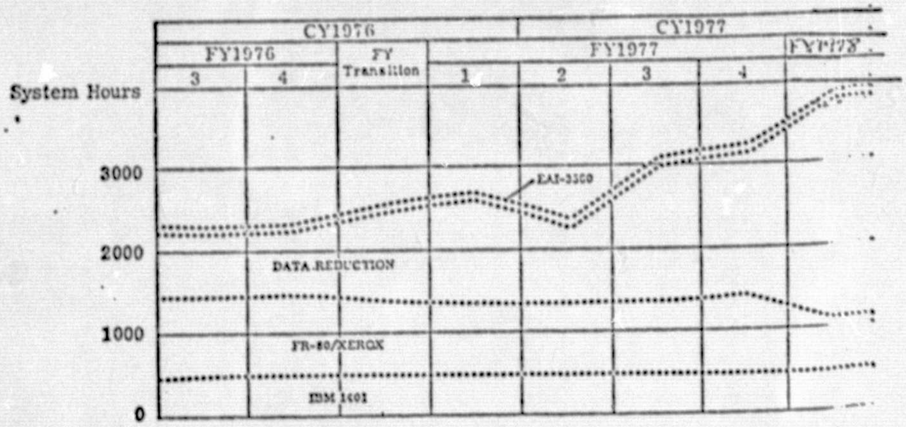
OTHER SYSTEMS WORKLOAD

NAME: C. Robertson

DATE: 1/22/76

PROCESSING SYSTEMS

Data Reduction	Shifts	17 | 18 | 20 | 17 | 21
FR-80/Xerox	Shifts	16
IBM 1401	Shifts	16
EAI-3500	Shifts	2



NASA ACTIVITIES

Shuttle ET
    Fabrication
SSME
    First All-Up Firing
    MPTA Delivery

STA MPTA STA

A&PS

SLIDELL COMPUTER COMPLEX

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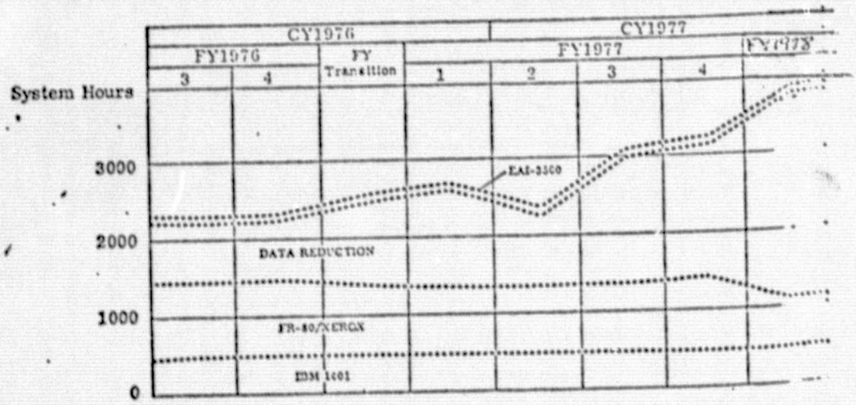

NASA ACTIVITIES

Shuttle ET
    Fabrication
SSME
    First All-Up Firing
    MPTA Delivery

STA MPTA STA

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TABLE 1-1

TABLE 1-2

CONSUMPTION OF ELECTRICITY

CALENDAR YEAR	1973			1974			1975			1976		
MONTH	DEMAND 1/ (kw)	USAGE (kwh)	COST (Dollars)	DEMAND (kw)	USAGE (kwh)	COST (Dollars)	DEMAND (kw)	USAGE (kwh)	COST (Dollars)	DEMAND (kw)	USAGE (kwh)	COST (Dollars)
January	NA	897,700	9,885	1,102	745,200	9,402	1,152	665,900	11,846	1,267	654,100	13,063
February	NA	753,400	8,958	1,117	660,700	9,448	1,186	617,600	11,396	1,313	693,700	14,363
March	NA	781,700	9,334	1,229	706,100	10,854	1,229	657,000	11,998			
April	NA	839,400	9,744	1,236	771,500	11,101	1,217	663,800	12,384			
May	NA	778,800	9,349	1,236	764,800	10,779	1,244	726,400	14,045			
June	NA	869,500	10,106	1,260	778,200	11,345	1,346	791,500	15,399			
July	1,382	1,000,200	11,001	1,267	847,300	12,889	1,328	732,900	14,691			
August	1,344	843,700	9,943	1,260	781,200	12,261	2,381 2/	833,800	18,450			
September	1,337	840,500	10,006	1,267	781,400	13,276	2,043 2/	822,200	18,052			
October	1,321	850,200	10,489	1,279	766,200	12,329	1,359	690,100	13,913			
November	1,317	738,100	9,684	1,332	728,500	12,640	1,344	627,600	12,902			
December	1,217	713,122	9,375	1,114	660,000	11,660	1,267	659,500	13,884			
TOTALS	-	9,905,322	$117,874 3/	-	8,991,100	$137,984 3/	-	8,488,300	$168,960 3/			

1/ Demand established by adding individual demands of building and electronic services.

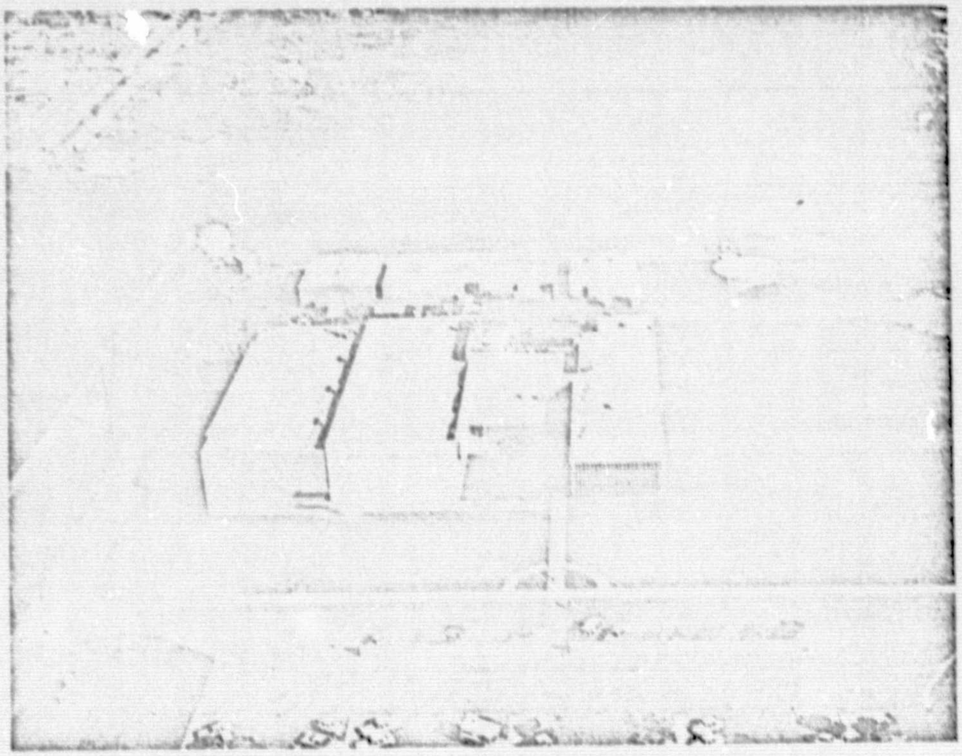
2/ High demands caused by testing of UPS System; not considered representative.

3/ Demand billing is approximately 16 percent of cost.

NATURAL GAS CONSUMPTION

CALENDAR YEAR	1973		1974		1975		1976	
MONTH	USAGE (CCF)	COST (Dollars)	USAGE (CCF)	COST (Dollars)	USAGE (CCF)	COST (Dollars)	USAGE (CCF)	COST (Dollars)
January	21,102	1,083	23,439	1,292	22,588	1,770	22,153	2,604
February	14,424	788	19,126	1,076	17,845	1,556	25,021	2,917
March	12,772	655	24,036	1,332	17,757	1,520		
April	17,837	893	17,066	1,043	20,157	2,106		
May	14,289	717	24,663	1,688	15,425	1,845		
June	14,063	708	17,566	1,208	16,994	1,773		
July	20,665	1,014	19,443	1,460	15,191	1,616		
August	16,174	806	17,728	1,338	15,853	1,791		
September	16,315	851	22,855	1,710	17,395	1,764		
October	15,556	815	20,648	1,545	13,393	1,506		
November	23,332	1,195	19,289	1,528	12,297	1,390		
December	20,183	1,043	24,079	1,892	18,127	2,050		
TOTALS	206,712	$10,568	249,938	$17,114	203,022	$20,693		

TABLE 1-3



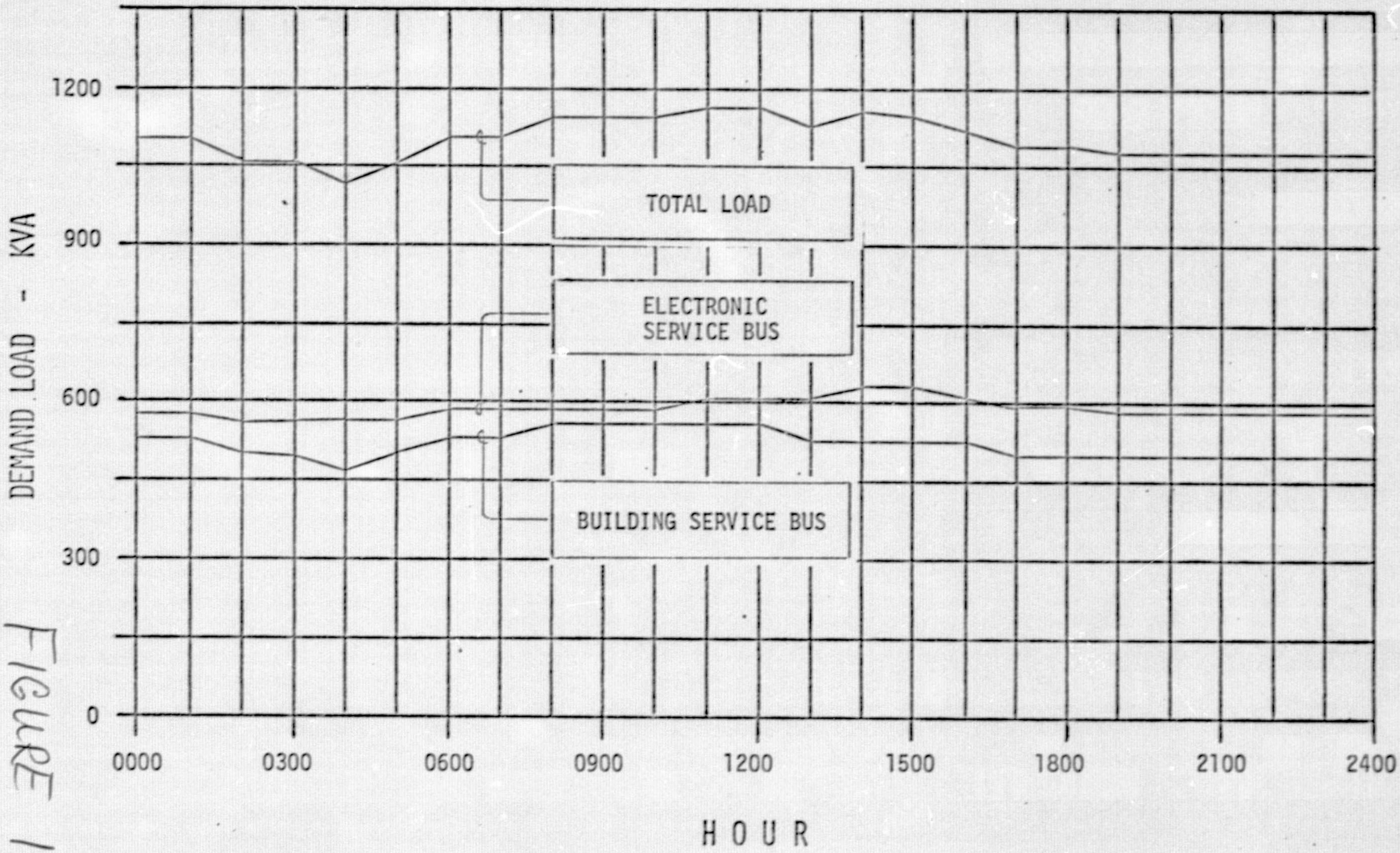
AERIAL VIEW OF

SLIDELL COMPUTER COMPLEX

Figure 1-1

SLIDELL COMPUTER COMPLEX

TOTAL ELECTRICAL DAILY LOAD CURVE



8-1

FIGURE 1-2

should be in exhibits section

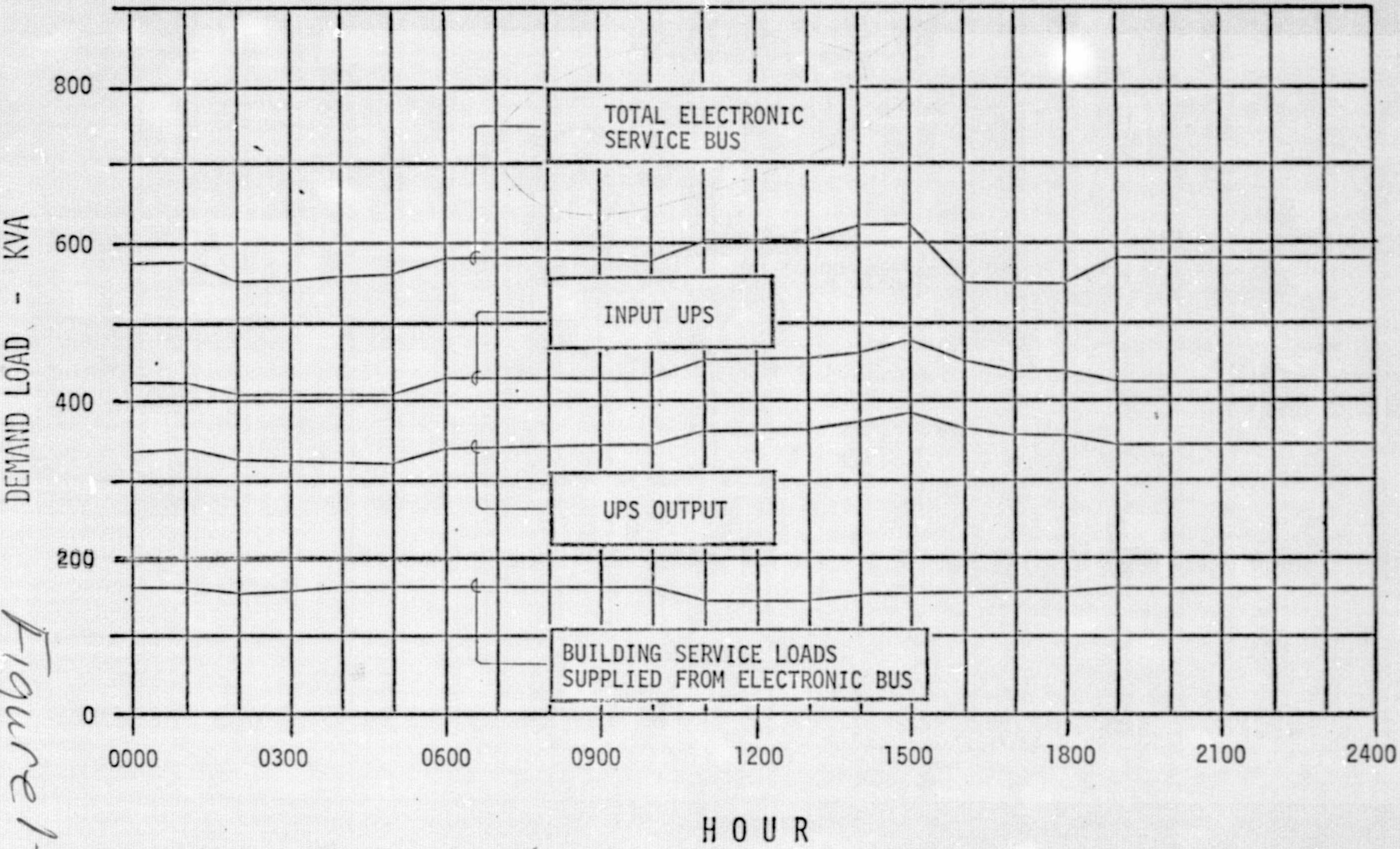
17 MARCH 1976

KG FORM E-3 NOV. 1974

SLIDELL COMPUTER COMPLEX

ELECTRONIC SERVICE DAILY LOAD CURVE

? does not agree @ 1-2



17 MARCH 1976

1-9

Figure 1-3

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SECTION 2

DESCRIPTION OF EXISTING SYSTEMS

SECTION 2

EXISTING SYSTEMS

This section describes the existing heating, ventilating, and air conditioning systems, the electrical system, the lighting system, and miscellaneous other energy-consuming systems. A site plan and floor plans of the Main Building are presented in Figures 2-1 through 2-4.

Heating, Ventilating, and Air Conditioning System

The heating, ventilating, and air conditioning system of the complex consists of two plants, two motor control and monitoring centers, and 32 air handling units located in the Main Building. There are six basic types of air handling units: (1) cooling only--single zone; (2) heating and cooling--single zone; (3) heating, cooling, and humidification--single zone; (4) multizone; (5) mix box--high velocity; and (6) terminal reheat.

A summary description of the existing air handling units is provided in Table 2-1.

Plant 1 (Room B46)

The cooling equipment in this plant consists of two Trane Centrivac chillers with 205 tons capacity each, one Carrier centrifugal chiller with 192 tons capacity, and auxiliaries. The chilled water supply and return lines for Plants 1 and 2 are interconnected. Therefore, chilled water can be supplied to the cooling coils of the 32 air handling units by either plant. The heating equipment in Plant 1 consists of two

37-1/2 BHP Kewanee steam boilers. The boilers are designed for operation at 15 psig. Two hot water converters located in the plant serve the heating coils of 17 air handling units.

This plant provides steam for two converters, the cafeteria, two hot water generators, and grid-type humidifiers in five air handling units. Condensate is returned by gravity.

A direct-fired gas hot water heater of 300,000 Btuh input capacity, with a 220-gallon tank, is installed but not in use.

Plant 2 (Room 115)

The cooling equipment in this plant consists of a 350-ton Trane Centrivac chiller and auxiliaries.

The heating equipment consists of two 37-1/2 BHP Kewanee steam boilers, designed to operate at 15 psig. Actual operating pressure is about 12 psig. A hot water converter serves the heating coils in 14 air handling units.

This plant provides steam for the converter and grid-type humidifiers in 14 air handling units. Condensate is returned by gravity.

Central Controls

In Plant 1 there is an operator's monitoring and control panel, part Honeywell and part Powers, with visual displays, gauges, and motor control panels. Air handling units 12, 13, 14A, 15A, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, and 26 (old numbers) are controlled from this location.

There is an additional control panel in Basement Room B-3 which control air handling units 1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 14, and 15 (old numbers).

Air handling units 9, 12A, 27, 31, and 32 (old numbers) are controlled at the unit. Section 3, "Analysis of Existing Systems," discusses local controls.

The interior environmental conditions presently established for the complex are:

	Summer	Winter
Computer Areas:		
Temperature	72°F	72°F
Humidity (maximum)	50%	50%
Office Areas:		
Temperature	78°F	68°F

The estimated annual energy usages are:

Heating and humidification (steam)	2.1×10^9 Btu/year
Air Conditioning (elec.)	14.8×10^9 Btu/year

Heat-to-control is not included. This will be discussed in detail in Section 3.

Electrical System

The complex is served by two Central Louisiana Electric Company aerial 34.5 kv feeders, from the company's LP&L and Slidell substations. One feeder normally serves the electrical load; in the event of a failure, the other is automatically switched to provide service. A utility company substation on the site steps down the voltage to 480/277 volts through two separate transformers, one for building service and the other for electronic service.

The 480/277 volt services are extended to a main switchboard in the Maintenance Building. From there, the building service is extended in underground conduits and through panelboards to its utilization points. The electronic service is extended to an Uninterrupted Power Supply (UPS) located in a building adjacent to the Main Building. The UPS consists of rectifiers, inverters, batteries, and auxiliary equipment to provide a continuous, transient-free source of electrical energy to the sensitive computer equipment. The battery will support the load for a period of approximately 10 minutes. The system is new and had been operational for only three months at the time of the field survey. From the UPS, 120/208 volt service is extended in conduits and through panelboards to the computer equipment. A small portion of the load, served from the electronic bus, is used for building service. This portion of the service bypasses the UPS system.

The estimated annual usage of the electronic system is:

Electronic (computer)	8.90×10^9 Btu/year
Losses in UPS	2.00×10^9 Btu/year

Interior Lighting Systems

The basic lighting system in the occupied spaces consists of 40-watt fluorescent lamps, designed to provide from 50 footcandles to 70 footcandles of illumination. Corridors, toilet rooms, stairwells, and exits generally utilize fluorescent fixtures; however, incandescent fixtures are installed in some locations as listed below:

Stairwells	23 fixtures
Rest Rooms	49 fixtures
Mechanical Rooms	23 fixtures
Exits	15 fixtures

As part of the overall energy conservation program, the illumination levels have been drastically reduced. Some 7,200 40-watt fluorescent lamps were installed originally--this number has now been reduced to 2,850.

It is estimated that electricity consumption for lighting was 2.03×10^6 kwh/year and is now reduced to approximately 0.8×10^6 kwh/year.

Exterior Lighting

The exterior lighting provides for security and personnel safety. Thirty-three 400-watt mercury units have been installed. In March 1976 eleven of the units were connected and twenty-two had been disconnected.

It is estimated that electrical consumption for exterior lighting was 65,000 kwh/year and has now been reduced to 21,000 kwh/year.

Domestic Hot Water System

The domestic hot water system serves lavatories, four showers, and a dishwasher. The hot water is provided by two hot-water generators located in Plant No. 1 and supplied from the steam system. It is estimated that the system uses 0.37×10^9 Btu/year.

Kitchen Equipment

A relatively small amount of kitchen equipment is installed to support the Cafeteria, Room 144. The equipment consists basically of the following items:

1 - Steam kettle
1 - Steamer
1 - Oven grill
1 - Dishwasher with booster heater

1 lot - Refrigerators, icemakers, warmers, and canteen-type dispensers.

The kitchen has a very low energy usage. It is estimated that the equipment uses:

Steam (exclusive of hot water for dishwasher)	0.035×10^9 Btus/year
Electricity	0.167×10^9 Btus/year

SUMMARY OF AIR HANDLING UNITS

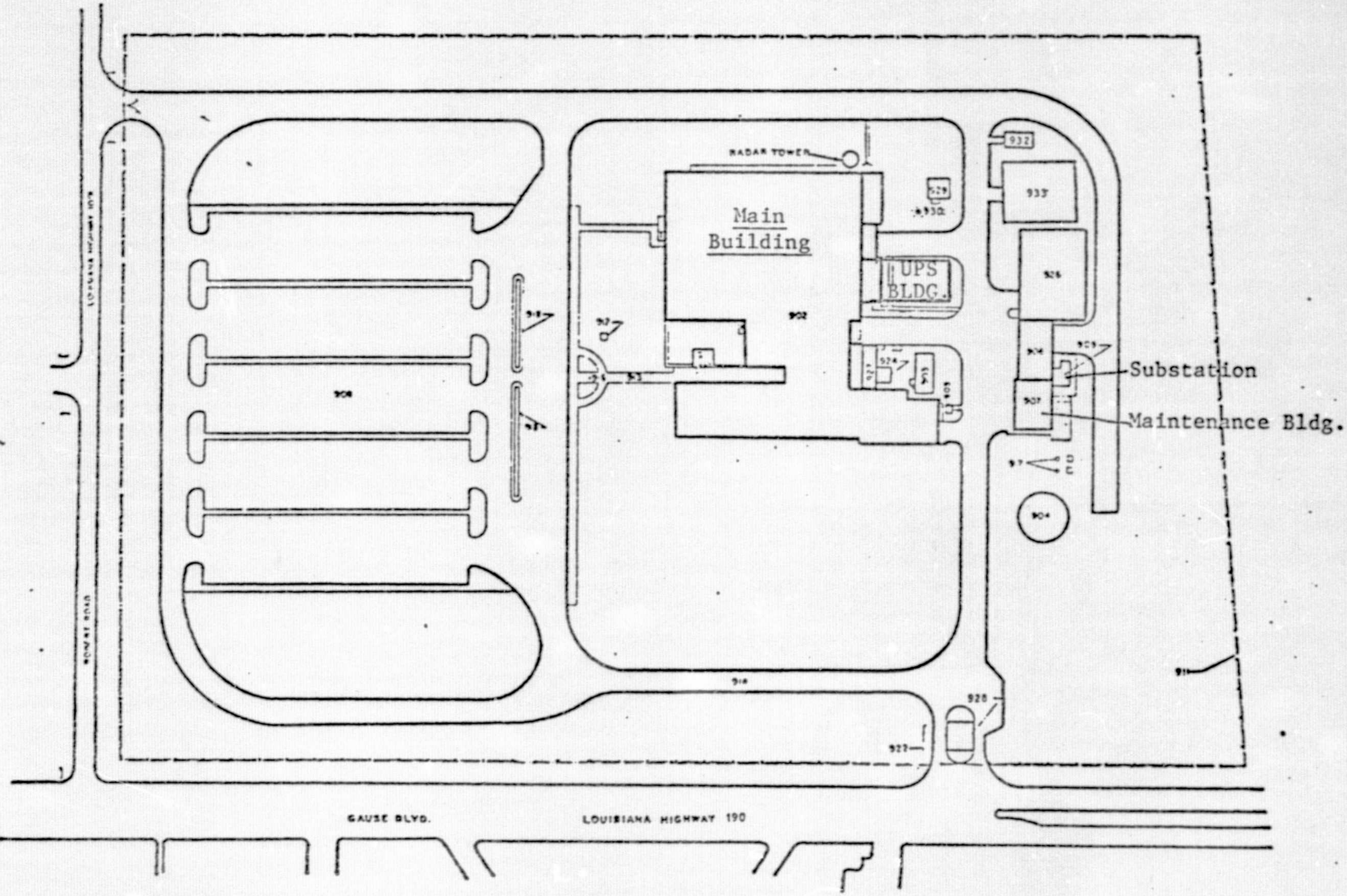
AHU NUMBER		TYPE OF SYSTEM*	NO. ZONES	LOAD TYPE**	FAN MOTOR			FAN		COIL FACE AREA (SQ. FT.)	COOLING COILS			HEATING COILS			HUMIDIFIER			PLANT NO. (HEATING)
											CHILLED WATER		MBTUH (CALC) 10°ΔT	HOT WATER		MBTUH (CALC) 20°ΔT				
NEW	OLD				V	HP	RPM	RPM	CFM		GPM	ENT/LV-°F		GPM	ENT/LV °F		TYPE	SIZE #/HR	PSIG	
1	25	HCH	1	C		5	1750	737	8190	16.1	68.4	44/54	342	12.6	180/160	126	ST.	45	10	2
2	26	HCH	1	C		5	1725	744	9700	19.7	81.0	↓	405	15.0	↓	150	ST.	83	10	2
3	5	HC	1	E&C	208	15	1800	825	3990	27.0	55.0	45/51	416	16.0	200/160	160	—	—	—	1
4	6	HCH	1	C	440	7½	1760	660	10350		57.5	45/55	526	22.7		227	ST			1
5	7	HC	1	E&C	208	7½	1800	760	4030	↓	47.0	45/53	372	13.0		130	—	—	—	1
6	8	HCH	1	C	440	2	1755	720	6300		25.8	45/55	263	11.4	↓	114	ST			1
7	31	HC	1	E	208	2	1800	1170	3120	5.6	18.0		86	4.0	180/160	40	—	—	—	1
8	32	HC	1	E	208	1	1800	1605	1750	3.0	11.0	↓	55	4.0	↓	40	—	—	—	1
9	14	HCH	1	E&C	440	20	1750	440	25,000	42.8	183.0	45/53	750	53.0	120/100	530	ST.	111	2	1
10	15	HCH	1	E&C	440	20		440	25,000	42.8	183.0	↓	750	53.0	↓	530	↓	111	2	1
11	12A	HCH	1	C	440	2		795	5,300	6.5	45.0	45/55	252	22.0		220	—	—	—	1
12	17	HCH	1	E	440	5		745	16,165	19.7	50.5	44/54		5.5	180/160	55	ST.	45	10	2
13	18	HCH	1	E	440															
14	19	HCH	1	E																
15	20	HCH	1	E																
16	21	HCH	1	E																
17	22	HCH	1	E			↓													
18	23	HCH	1	E			1725													
19	24	HCH	1	E		↓	1750	↓	↓	↓	↓		↓	↓		↓		↓		
20	13	HCH	1	C		2	1725	690	4235	8.7	26.7		133	3.7		37		29		
21	14A	HCH	1	C		5		747	10175	19.7	64.5		320	9.2		92		71		
22	15A	HCH	1	C			↓													
23	16	HCH	1	C		↓	1750	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
24	1	HC	1	C		7½	1760	750	4000	30.6	32.2	45/55	464	12.4	200/	42	—	—	—	1
25	2	HC	1	E&C					3910		35.8			14.3			—	—	—	
26	3	HC	1	E&C					6650		45.3			18.9			—	—	—	
27	4	HC	2 (1 CLOSED)	E&C		↓	↓	↓	16000	↓	84.6	↓	↓	32.2	↓	↓	—	—	—	↓
28	9	C	1	E		2	1755	1000	4000	7.5	23.0	45/53	92	—	—		—	—	—	
29	12	HCH	1	E		¾	1725	800	1590	4.2	19.0	44/54	75	2.6	180/160	26	ST	176	10	1
30	10	MULTI ZONE	3	E&C		5	1740		6070	11.7	76.0	45/53	304	15.0	200/	150	—	—	—	
31	11	MIX BOX HIGH VEL	18	C		40	1775	1850	13700	30.7	22.9	45/53	953	56.0	200/	500	—	—	—	
32	27	TERMINAL REHEAT	4	C	↓	5	1725	814	7610	15.4	46.5	44/54	232	—	—		—	—	—	↓

* HCH is heating and cooling coils with humidification; HC is heating and cooling coils; C is cooling coils only.
** C is comfort conditioning for office spaces; E is equipment conditioning for computer spaces.

2-7

Table 2-1

ORGANIZATION: A&PS SLIDELL COMPUTER COMPLEX	MARSHALL SPACE FLIGHT CENTER SLIDELL COMPUTER COMPLEX SITE PLAN	NAME: DATE:



2-8

Figure 2-1

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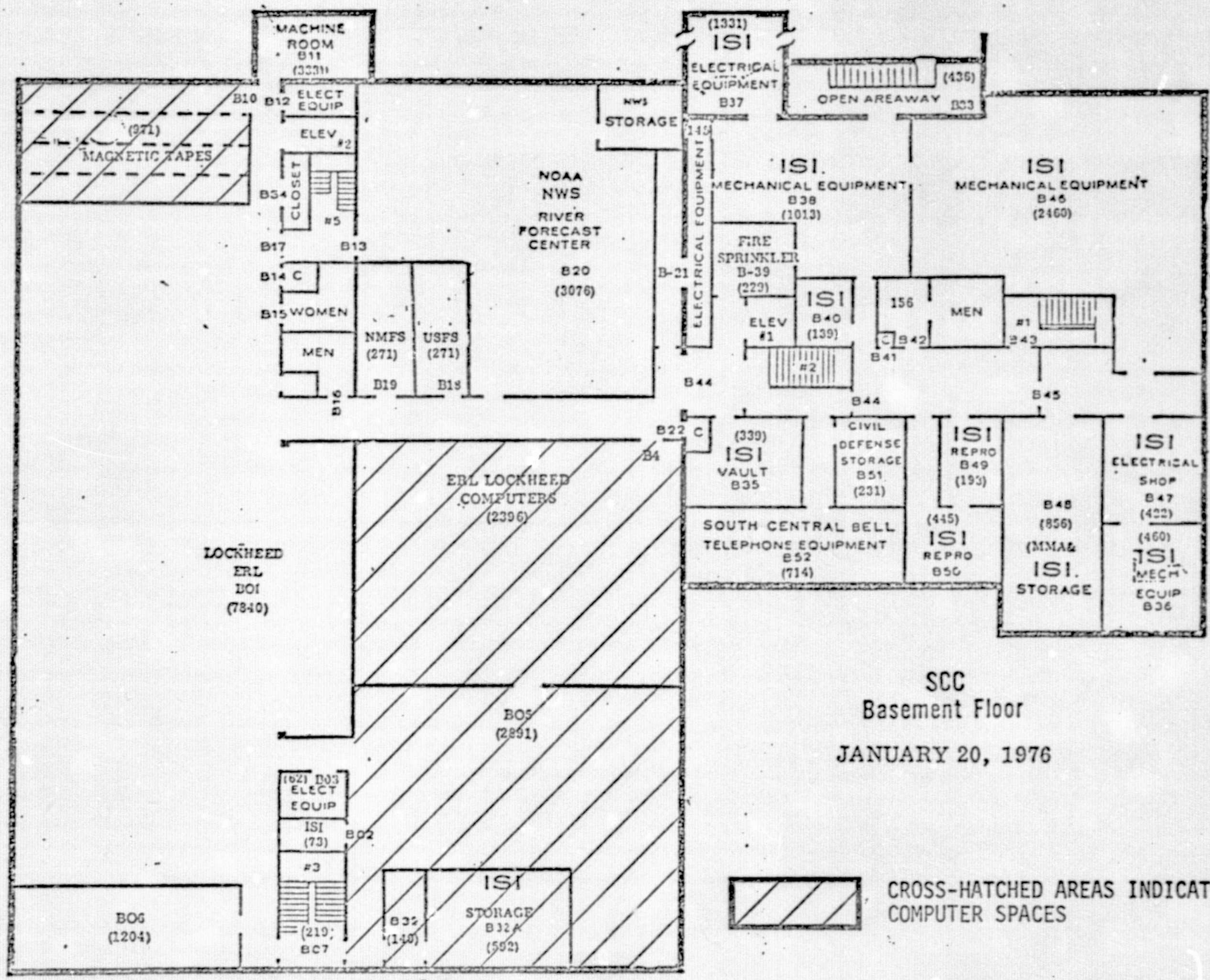

SCC
Basement Floor

JANUARY 20, 1976

CROSS-HATCHED AREAS INDICATE
COMPUTER SPACES

Number in Parenthesis is the Net Floor Area in Square Feet

2-9 Figure 2-2

FIGURE 2-2

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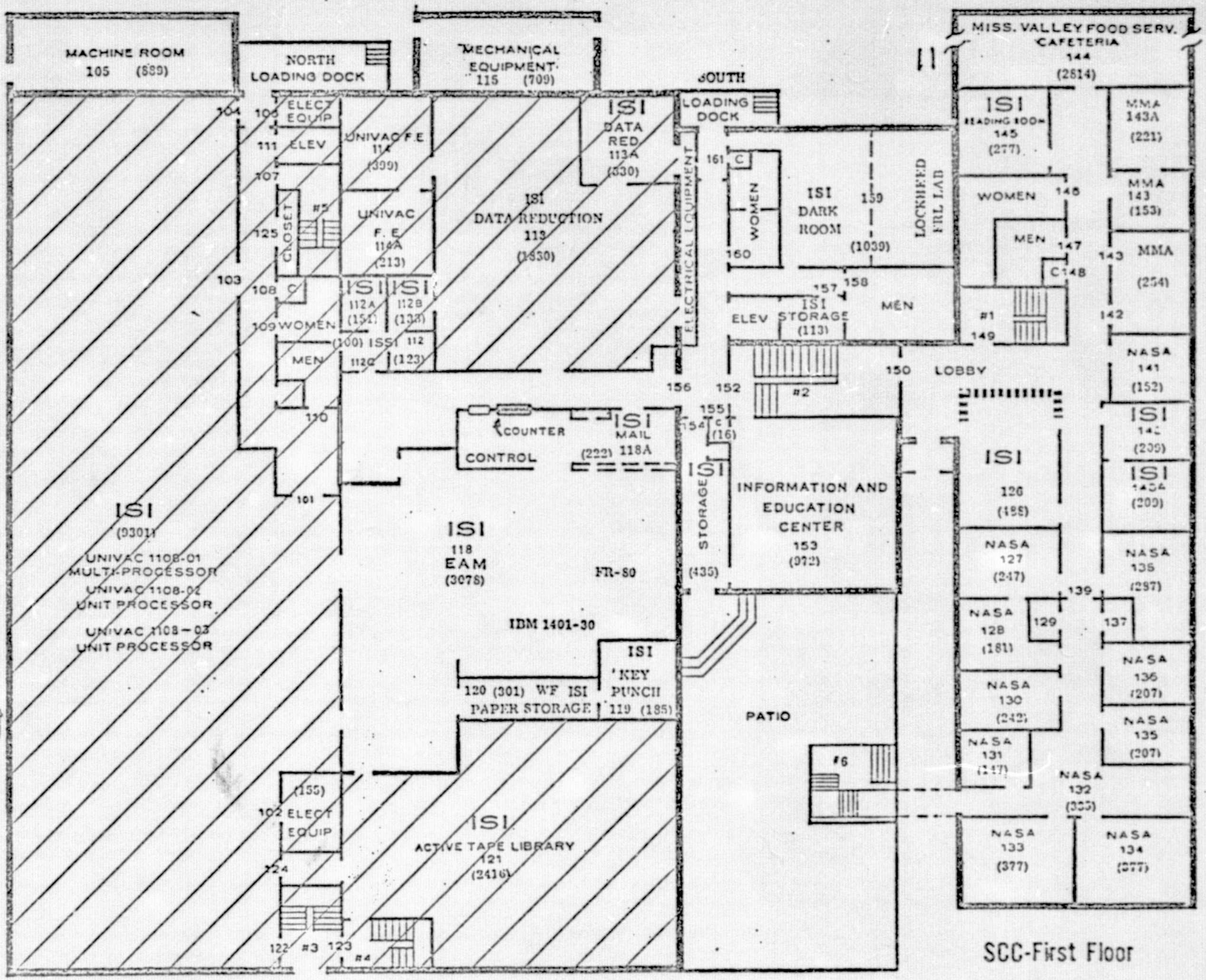

Number in Parenthesis is the Net Floor Area in Square Feet

SCC-First Floor

MARCH 15, 1976

CROSS-HATCHED AREAS INDICATE COMPUTER SPACES

2-10 Figure 2-3

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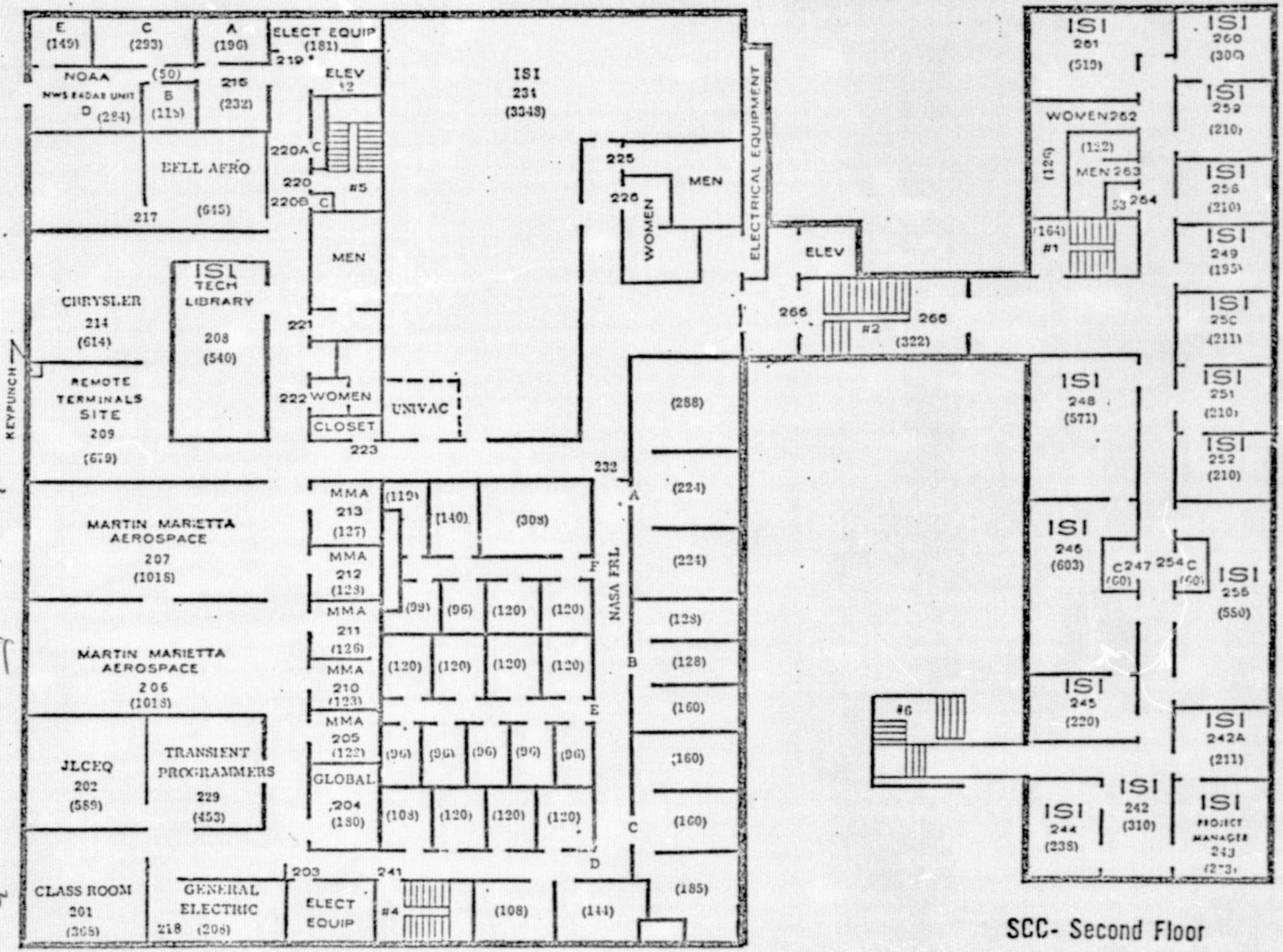
2-11 Figure 2-4



Number in Parenthesis is the Net Floor Area in Square Feet

SCC- Second Floor
MARCH 1976

SECTION 3

ANALYSIS OF EXISTING SYSTEMS

SECTION 3

ANALYSIS OF EXISTING SYSTEMS

General

In analyzing an energy-consuming system, it is important to assess the relative magnitude of usage by each of the systems involved. Annual usage for calendar year 1976 has been estimated, taking into account:

- The increased activity at the complex, as indicated by the increase in personnel from 260 in the fall of 1975 to 375 in March 1976.
- The continued efforts of the site personnel to reduce energy consumption.
- The losses of the UPS system, which will operate for a full 12-month period in 1976 as compared to three or four months in 1975.

Estimated annual energy usage based on conditions found at the time of the survey is shown in Table 3-1.

TABLE 3-1
ESTIMATED ENERGY USAGE BY MAJOR SYSTEMS

SYSTEM	ENERGY USAGE 10^9 Btu/year	
	ELECTRICAL	NATURAL GAS
Interior lighting	2.50	-
Exterior lighting	0.07	-
Electronic (Computer)	8.90	-
UPS losses	2.00	-
Domestic hot water	-	0.37
Kitchen equipment	0.17	0.04
Heating - Main Building	-	1.50
Heating to control:		
Dehumidification/reheat/heating	-	8.72
Humidification	-	0.60
Air conditioning and ventilation	14.80	-
Boiler/steam-hot water conversion/ distribution losses	-	7.77
Miscellaneous	0.56	1.30
TOTAL	29.00	20.30

Heating, Ventilating, and Air Conditioning

The heating, ventilating, and air conditioning systems have been installed in increments since 1962, as additions to the building were constructed. The installed systems have also been modified several times to accommodate the changing workload of the complex, the layout of computer equipment, and requirements for functional changes in building spaces. As a result, in several instances a single air handling unit serves both computer and office spaces. In other cases, air handlers serve either a computer space or an office space. See Table 2-1. In the basement area some of the offices are too cold because air in the underfloor and overhead plenums, supplying computer spaces, infiltrate into office spaces.

Heating

The basic heating units are steam boilers. A review of load data and discussions with operator personnel indicate that the boilers in Plant 1 are overloaded at times during the heating season (1 November through 15 April). The overload condition causes a drop in steam operating pressure from approximately 12 psig to 6 psig.

The condensate return tanks in Plants 1 and 2 are too small. As a result, the tank in Plant 1 periodically overflows onto the floor and into piping trenches. In Plant 2 the condensate tank periodically discharges through an overflow pipe to the plant drainage system. The flooding in Plant 1 is due in part to the boiler overload. Check valves are required in condensate feed lines at the boilers in Plant 1. Approximately 0.5 hour is required each shift to clean up Plant 1 after occurrence of overflows. In addition to the heat loss of the condensate, more feedwater treatment is required for makeup water.

At least 90 percent of the heat energy provided by the 4 existing steam boilers is converted to hot water in the plants. Converters provide hot water for air handling unit coils, and domestic hot water is provided by steam coils (generators).

Installation of new hot water boilers and a supply and return cross connection between plants has the following advantages:

a. More efficient boilers.

b. A 50 to 75 percent reduction in water treatment chemicals.

c. Reduction of heat transmission and conversion losses.

d. Improved boiler loading.

e. Reduced maintenance costs.

The changeover can be made easily because existing closed loop hot water distribution systems can be utilized and also existing circulating pumps.

All heating coils in the air distribution systems are hot water. All humidifiers in the air distribution systems are steam grid type. Because there is almost no demand for humidification during the cooling season (15 April to 1 November), and perhaps because of problems with traps, condensate collects in the steam distribution piping. Therefore, the steam-grid humidifiers sometimes operate with water instead of steam. This causes the water to overflow into ducts and working spaces.

A domestic hot water generator (steam coils) in Plant 1 serves the Cafeteria areas. A domestic hot water heater (direct-fired gas) which could be used to serve the Cafeteria is not in use. The heater is

cross-connected to a second domestic hot water generator which serves the remainder of the building. Operation of the direct-fired heater will provide a more efficient use of energy.

Cooling

The basic cooling units are centrifugal compressors. Total nameplate capacity of the compressors in both plants is 963 tons of refrigeration. Total cooling coil capacity in the 32 air handling units is 903 tons.

The chilled water lines of Plants 1 and 2 are cross-connected. The water is run through the chillers during cross-connection to ensure prompt startup of standby capacity in event of malfunction of an on-line unit. This is considered necessary to protect computer equipment.

Humidity requirements constitute a large portion of the cooling load, which is in addition to thermal and solar loads and heat gains in the conditioned spaces. There is a 42 percent or higher occurrence of ambient relative humidity of 80 percent or higher for each month of the year.

Air handling unit 9 (old number) serves the Electrical Switchgear Room on the east side of the building. The unit has only a cooling coil. Mechanical ventilation is adequate for the switchgear. Automatic door closers should be provided on the two doors of the room to reduce the flow of outside air and hot air from Plant No. 1.

Heating and Cooling Controls

Local controls on air handling units are pneumatic. Portions of a control system for radiological safety remain in the original construction areas of the building. Some fans and dampers are utilized--others are not. Controls are maintained under a contract with Honeywell, Inc.

There are no return fans on existing air distribution systems, except AHU No. 12.

Economizer cycles and total enthalpy damper controllers were analyzed for control of outside air. Neither type of control is recommended because the average number of heating degree days per year is less than 2,500 and because of the high incidence of ambient relative humidity over 80 percent.

During the heating season (1 November to 15 April), thermostats in the comfort conditioned spaces have been set at 68° in accordance with current criteria. During some of the warmer days in the heating season, cooling is required to bring the spaces to this temperature. A control is required to lock out the cooling coil during the heating season.

Air handling units 10 and 11 (old numbers) do not have hot and cold deck reset controls to keep temperature differentials to a minimum. Readings on unit 10 (multizone) indicated a 41°F differential and on unit 11 (mix box) a 42°F differential. A load analyzer and reset controller will save energy on these systems.

Automatic stop-start controls for air handling units will save both energy and manpower. Existing stop-start controls are not centralized in one location and require visits to at least two and sometimes more

locations to start and stop the units. Sequential cycling of air handling unit fans and shutdown of air handling units during nights and weekends can be programmed in real time by an automated system.

Sensors and controls are required in 16 locations in the plenums serving the Univac 1108 computer areas. Ten air handling units serve these areas. The sensors should be portable, with a capability of sensing both relative humidity and dry bulb temperatures. High level and low level alarms should be integrated with the sensors to warn operating and facilities personnel of conditions which may be harmful to computer equipment.

Building Envelope

High traffic entrances of Building 902 have vestibules with self-closing doors.

Window areas of the building are adequately shaded by either adjustable exterior motor controlled vertical louvers or "Kool shades." The exception is one window area on the west side of the Conference Room of approximately 90 square feet. This window has draw draperies and is also shaded by the Administrative Wing of the building.

A roofing repair project has been submitted for funding. All reroofing projects should specify white surface materials to reduce solar heat gain.

Heat transmission coefficients for walls, ceilings, and roofs are satisfactory except for the Administrative Wing. The "U" factor for approximately 7,400 square feet of office space and 3,400 square feet

in the Cafeteria is .10. Additional ceiling insulation should be installed for an overall "U" factor of .05.

Electrical System

It was reported that the electronic (computer) system usage had been reduced to the minimum commensurate with the mission requirement of the complex. No equipment is being maintained on a ready-standby status unless absolutely essential.

The UPS, which provides continuous, transient-free energy to the computer equipment, was made fully operational in January 1976. It was reported that this system, even in its relatively short usage period, had dramatically reduced computer outages and maintenance. However, the system operates at approximately 82 percent efficiency, with a resultant use of 580,000 kwh in a year. There is no practical method of reducing this usage without severely reducing the quality and the reliability of the electrical service.

The miscellaneous electrical equipment usage appeared to be small and at an acceptable minimum.

Lighting Systems

As mentioned in Section 2, some 60 percent of the fluorescent lamps throughout the complex have been removed in the past 18 months. The resulting system generally provides 50 footcandles on desk tops, with much lower values occurring on adjacent tables and files. It appears that the illumination has been reduced to an absolute minimum, (and possibly, in some instances, to a less than acceptable minimum).

A manual monitoring system is used to ensure that all lighting fixtures are turned off when areas are not occupied.

Some incandescent fixtures are used in stairwells, toilet rooms, mechanical rooms, and exits. It is estimated that the replacement of these units with fluorescent units will result in a savings of 42,000 kwh/year.

When the fluorescent lamps were removed, the ballasts were not disconnected. This results in a loss of 6.5 watts for each two-lamp, 40-watt ballast. Based on an average burning time of 3,000 hours/year, the energy usage is:

$$\frac{4{,}350 \text{ lamps removed}}{2} = 2{,}175 \text{ ballasts}$$

$$\frac{2{,}175 \text{ ballasts} \times 6.5 \text{ watts} \times 3{,}000 \text{ hours}}{1{,}000} = 42{,}400 \text{ kwh/year}$$

Manufacturer's data on ballast losses are shown in Table 3-2.

Domestic Hot Water System

The energy usage of the domestic hot water system is very small. The temperature of the water was being lowered to a minimum value during the field survey.

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Kitchen Equipment

The Cafeteria kitchen was reported to be very lightly used. Management should consider alternative methods of food handling such as catering, increased use of vending machines, disposable plates, or other methods which could be balanced against a potential energy saving of 0.41×10^9 Btu/year.

FLUORESCENT HID BALLASTS

MARKETING NEWS
Spec. 2
November 16, 1973

BALLAST DEPARTMENT . . . 1430 EAST FAIRCHILD STREET, DANVILLE, ILLINOIS 61832 . . . TELEPHONE 446-4600

ENERGY CONSERVATION

Ballast Operation
Lamps Removed

The current energy crisis has caused users to look for ways to reduce power consumption. One method being utilized is to remove lamps from energized fixtures. When both lamps are removed from a two-lamp ballast circuit, a small amount of power is still consumed as the ballast draws magnetizing current. The table shows this amount (watts loss) for major GE ballast lines.

Two Lamp Family	Watts Loss Per Ballast With Both Lamps Removed
430 ma Rapid Start (8G1022, 8G1032)	6.5 W
800 ma High Output (8G1141, 8G1151)	12.5 W
1500 ma Power Groove (8G1201, 8G1211)	13.5 W
425 ma Instant Start (8G1011, 8G1015)	13.0 W
(8G1490, 8G1532)	11.0 W

System Performance

- Power factor will remain above 95% provided not more than half of the lamps in an installation are removed.
- Ballast life is not adversely affected if both lamps are removed.
- Removal of only one lamp from a two-lamp ballast circuit can seriously affect ballast life and can cause immediate (hours) failure.

NOTE: GENERAL ELECTRIC DOES NOT RECOMMEND REMOVAL OF ONE LAMP FOR ANY REASON. THIS IS AN ABNORMAL CONDITION AND VOIDS THE PRODUCT WARRANTY.

Lamps from single lamp fluorescent, mercury and metal halide ballasts may be removed with no adverse affect. Do not remove high pressure sodium lamps or the starting circuit will be damaged. If the lights cannot be switched off, the ballast should be disconnected from the line. Additional information concerning ballast operation and energy conservation is available upon request. For prompt reply, please send your inquiries to this department marked "Energy."

BALLAST BUSINESS DEPARTMENT
General Electric Company

GENERAL ELECTRIC

Table 3-2

SECTION 4

RECOMMENDATIONS

SECTION 4

RECOMMENDATIONS

General Considerations

In developing the recommendations, a simple payback method was utilized. The payback period for each recommendation is listed in the summary in Section B.

Current construction costs were utilized for engineering and budget estimates. Savings were estimated on the following basis:

	Escalation	Base Unit Costs (February 1976)
Electricity	25%/year	\$ 0.02/kwh
Natural Gas	30%/year	\$ 1.18/100,000 Btu
O&M	8%/year	\$ 6.15/hr (Labor)

The payback period (years) was determined by dividing the engineering cost estimate by the cumulative annual savings escalated in accordance with the foregoing. The number of years of cumulative annual savings required to amortize the estimated cost is the payback period.

It will be noted that budget estimates for recommendations in excess of \$10,000 include an allowance of 15% for contingencies, 24% for escalation (3 year period) and 5% for government cost. For budget estimates less than \$10,000 the escalation factor was not included.

The energy monitoring and control system was not escalated because it is considered that "state of the art" changes and competition will keep the costs stable for the next 3 years.

Recommendations

HVAC 1 - Use the existing direct-fired gas domestic hot water heater located in Plant 1 for the Cafeteria. Disconnect and remove the hot water generator (steam coils). This will reduce the load on the existing steam boilers and provide a more efficient means of obtaining hot water.

HVAC 2 - Increase (to approximately double) the size of condensate return tanks in both plants. Provide a check valve in the condensate feed line at each boiler - Plant 1.

HVAC 3 - Disconnect and remove all steam grid humidifiers and associated piping and controls from air distribution systems which provide office air conditioning only. This will effect both an energy and maintenance saving. Humidification for office environment is not considered essential at Slidell.

HVAC 4 - Remove and disconnect the steam unit heater in the kitchen area of the Cafeteria, including piping and controls. The heat emitted by the equipment is judged sufficient for the area.

HVAC 5 - Provide load analyzers on Air Handling Units 10 and 11 (old numbers), to allow a more optimum operation of the system with an accompanying savings in energy and maintenance.

HVAC 6 - Provide a lockout control actuated by a 68°F setting on thermostats, in office conditioned spaces only, so that the air conditioning portion of the system will not function at the 68°F setting. This will result in a saving in air conditioning energy.

HVAC 7 - Renovate the HVAC system in Electrical Switchgear Room and provide door closers. At the present time, the doors to the room are left open and the warm air from the adjacent Mechanical Room is exhausted through this room. An extremely large exhaust fan is provided, as is a unit with cooling coils. The recommended renovation includes removal of the large exhaust fan, removal of the cooling coils, providing door closers, and replacement with a simple, mechanical ventilating system. This will result in an energy and maintenance saving.

HVAC 8 - Remove Exhaust Fan No. 7 in the attic space. Open the exterior sets of louvers (from old radiological safety system) on both ends of building so that the attic thermostat can open or close the motorized interior louvers to provide ventilation in the attic space. This will result in energy and maintenance savings.

HVAC 9 - Revise basement duct work to provide a direct supply to the computer area, to allow the adjacent office space to have a separate temperature control and to minimize the "cold floor" problem. This problem is caused by the fact that the conditioned air to the computer space is presently supplied through an underfloor plenum in the office area. This will result in a rather large maintenance saving as well as an energy saving.

HVAC 10 - Remove existing steam-grid humidifiers in computer areas, and replace with individual room-type units with water, drain, and electrical connections. This will effect a saving in ? maintenance. and energy savings thru increased efficiency

HVAC 11 - Change out the four 37.5 horsepower steam boilers in Plants Nos. 1 and 2. Replace with two 75 horsepower hot-water boilers, and provide an interconnection between Plants 1 and 2, remove existing steam-to-hot water conversion equipment. This will provide a more efficient as well as better operating system, resulting in substantial energy and maintenance savings.

HVAC 12 - Provide additional insulation in roof area above office/ Cafeteria portion of building, to provide a "U" factor of 0.05.

P-1 - Set all domestic hot water controls to the 130°F to 140°F range. Ensure that washwater for the dishwasher in the Cafeteria is 140°F and rinse water (with steam coil booster) is 180°F.

L-1 - Provide additional switches to control fluorescent lights in fixtures so that optional control will be provided and the ballasts will be disconnected when the lamps are deactivated. Presently, the lamps have been removed from the fixtures, leaving the ballasts energized. Some 42,000 kwh per year could be saved by deenergizing the ballasts. In addition, if there are changes in occupancy, lamps must either be added or removed as the situation requires. In lieu of providing additional switches, the ballasts could be disconnected which would effect the same saving; however, the labor for reconnecting each ballast would be uneconomical.

L-2 - Replace existing incandescent lighting fixtures with fluorescent lighting fixtures in stairwells, toilet rooms, mechanical rooms and exits. This will accomplish an energy saving of 42,000 kwh/year.

E-1 - Provide capacitors to increase the power factor of the two utility company services to approximately 90 percent. This will reduce the electrical billing by $500/year and slightly reduce the copper (I^2R) losses within the complex.

Justify the pf need?

EM-1 - Provide an energy monitoring and control system consisting of both analog and digital points for control and monitoring, data gathering panels, and central control, with modular hardware and software.

The major programs will be electrical demand limiting and control, stop/start, sequential load cycling, and controllers for hot deck and cold deck temperature reset. The major monitoring points are humidity and temperature in the plenums serving the Univac 1108 computer areas. Alarms (high and low) are provided for these areas. Boiler alarms are also included for low water.

Central control will consist of a central processor, printer, visual displays, and an operator's keyboard.

There are approximately 40 temperature monitoring points on the existing panelboard in Plant 1 for air handling units. These points are not included in the recommended system. The points can be added as a future increment at an estimated

cost of $700 per point plus $5,000 for changes to software. Twenty-eight digital points should also be considered when the planned modifications are made to Roll-O-Matic filters in air handling units. The points would provide a maintenance alarm to indicate dirty filters. Estimated cost is $250 per point plus $2,000 for changes to software.

Summary

A summary of the impact on the overall energy usage at the complex, if all of the recommendatons are implemented, is listed in Table 4-1.

TABLE 4-1
ESTIMATED ENERGY USAGE BY MAJOR SYSTEMS
AFTER ALL RECOMMENDATIONS ARE IMPLEMENTED

SYSTEM	ENERGY USAGE 10^9 Btu/year	
	ELECTRICAL	NATURAL GAS
Interior lighting	2.218 (0.288)	-
Exterior lighting	0.07	-
Electronic (computer)	8.90	-
UPS losses	2.00	-
Domestic hot water	-	0.37
Kitchen equipment	0.17	0.04
Heating - Main Building	-	1.227 (0.273)
Heating to control:		
Dehumidification/reheat/heating	-	4.70 (4.02)
Humidification	-	0.60
Air conditioning and ventilation	13.468 (1.332)	-
Boiler/steam-hot water conversion/ distribution losses	-	4.20 (3.57)
Miscellaneous	0.56	1.30
TOTAL	27.38 (1.620)	12.437 (7.863)

Values in ( ) indicate savings.

The savings are tabulated in Section A and sample illustrations of the annual energy savings are shown in the Appendix. Almost all are self-explanatory. The reduction in boiler and conversion losses is attributed to the reduced boiler load and the increased efficiency of the hot-water boilers.

The estimated usage for dehumidification/reheat/heating was determined by a computer analysis of the existing system adjusted to simulate the present configuration of computer spaces and office spaces. The potential savings in load is attributed to:

a. Simultaneous heating and cooling of office spaces by air handling units originally designed to serve computer spaces.

b. Infiltration of cool air from underfloor/ceiling plenums into office spaces thus requiring reheat to meet comfort requirements.

c. Abnormal heating requirements of the system due to condensate losses and malfunctioning humidifiers.

The heating, ventilating, and air conditioning systems are not matched to existing internal loads. As internal heating and cooling loads have changed due to new space assignments and workloads, required (parallel) modifications to the heating, ventilating, and air conditioning systems have not always been made. Therefore, some of the HVAC systems are out of balance.

As a result of the tabulation and analysis of loads, another recommendation is added:

HVAC 13 - Provide an in-depth engineering analysis of the systems to accomplish the following:

a. Balance the air distribution.

b. Match HVAC equipment and motors to load--including elimination and/or replacement of some air handling units.

c. Rezone.

d. Relocate controls and thermostats.

c. Remove all unused portions of the old radiological safety system.

APPENDIX

A - COST ESTIMATES FOR RECOMMENDATIONS
(Items over $10,000)

B - SAMPLE ENERGY SAVINGS CALCULATIONS

HVAC 11

Date 3 APRIL 1976

STATION

SLIDELL COMPUTER COMPLEX

LOCATION

SLIDELL, LOUISIANA

PROJECT TITLE

PROVIDE SELF-CONTAINED HUMIDIFIERS IN COMPUTER SPACE (CABINET TYPE)

	ITEMS	QUANTITIES		ENGINEERING ESTIMATE		BUDGET ESTIMATE	
	DESCRIPTION	NO. OF UNITS	UNITS	UNIT COST	COST	UNIT COST	BUDGET COST
1.	Self-contained humidifiers	11	EA	$1,360	$15,000		
2.	Electrical, water and drain connections to units	11	EA	400	4,400		
	TOTAL ENGINEERING ESTIMATE				$19,400		
	TOTAL BUDGET ESTIMATE						$29,000

BUDGET ESTIMATE = ENGINEERING ESTIMATE [(1.00+C)(1.00+E)(1.00+GC)]

C = CONTINGENCY - 15%

E = ESCALATION FACTOR (3-YEAR PERIOD) - 24%

GC = GOVERNMENT COST - 5%

BUDGET ESTIMATE = ENGINEERING ESTIMATE [1.50]

A-1

HVAC 12 | Date 9 APRIL 1976

STATION: SLIDELL COMPUTER COMPLEX

LOCATION: SLIDELL, LOUISIANA

PROJECT TITLE:

REPLACE 4 STEAM BOILERS WITH 2 HOT WATER BOILERS
CROSS-CONNECT NEW HOT WATER BOILERS

ITEMS		QUANTITIES		ENGINEERING ESTIMATE		BUDGET ESTIMATE	
	DESCRIPTION	NO. OF UNITS	UNITS	UNIT COST	COST	UNIT COST	BUDGET COST
1	Remove steam boilers, converters and auxiliaries	LS	LS		$ 2,000		
2	Install 2 each 75 HP hot-water package boilers	2	EA	$8,000	16,000		
3	Install control package	2	EA	600	1,200		
4	Piping & insulation	LS	LS	3,000	3,000		
5	New foundation	2	EA	200	400		
6	Cross-connection between plants (4" piping with insulation-supply & return)	480	LF	25	12,000		
	TOTAL ENGINEERING ESTIMATE				$34,600		
	TOTAL BUDGET ESTIMATE						$51,900

BUDGET ESTIMATE = ENGINEERING ESTIMATE [(1.00+C)(1.00+E)(1.00+GC)]

C = CONTINGENCY - 15%
E = ESCALATION FACTOR (3-YEAR PERIOD) - 24%
GC = GOVERNMENT COST - 5%

BUDGET ESTIMATE = ENGINEERING ESTIMATE [1.50]

A-2

COST ESTIMATE

EMI		Date 9 APRIL 1976
STATION	LOCATION	
SLIDELL COMPUTER COMPLEX	SLIDELL, LOUISIANA	

PROJECT TITLE

ENERGY MONITORING & CONTROL SYSTEM

ITEMS		QUANTITIES		ENGINEERING ESTIMATE		BUDGET ESTIMATE	
	DESCRIPTION	NO. OF UNITS	UNITS	UNIT COST	COST	UNIT COST	BUDGET COST
1	Central control: hardware, software and programs	EA	1	$30,000	$30,000		
2	Meters and pulse initiators	EA	2	500	1,000		
3	Points	EA	136	450	61,200		
4	Controllers	EA	4	200	800		
5	Data gathering panels	EA	6	1,000	6,000		
	TOTAL ENGINEERING ESTIMATE				$99,000		
	TOTAL BUDGET ESTIMATE						$104,000

BUDGET ESTIMATE = ENGINEERING ESTIMATE [(1.00+C)(1.00+E)(1.00+GC)]
C = CONTINGENCY - 0%
E = ESCALATION FACTOR (3-YEAR PERIOD) - 0%
GC = GOVERNMENT COST - 5%
BUDGET ESTIMATE = ENGINEERING ESTIMATE [1.05]

HVAC 1

ANNUAL ENERGY SAVINGS

Use direct-fired gas DHW in lieu of hot water generator with steam coils for cafeteria - Plant no. 1.

ASSUMPTIONS

1. Load of DHW for cafeteria is 1200 gallons/day.
2. Direct fired heater is 15% more efficient than steam boiler.
3. Heat transfer losses and line losses will be reduced 5%.

CALCULATION

Energy Consumption

BTU

1200 GPD x 8.33 #/GAL. x $\triangle$ T = BTUS/DAY

1200 GAL./DAY x 8.33 #/GAL. x (150-75) x 365 DAYS/YR.

= BTU/YR. = 1200 x 8.33 x 75 x 260 = 194 x 10^6 BTU/YR.

$$\frac{194 \times 10^6 \text{ BTU/YR.}}{.65 \text{ EFF}} = 298 \times 10^6 \text{ BTU/YR.}$$

Energy savings = 298 x 10^6 BTU/YR. x 20% = 59.6 x 10^6 BTU/YR.

Energy savings ($) = 59.6 x 10^6 BTU/YR. x $1.18 = $71/YR.

This recommendation will reduce the load on overloaded boilers in Plant no. 1

APP. B-1

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HVAC 2

ANNUAL ENERGY SAVINGS

Double the size of condensate return tanks in Plants 1 & 2.

ASSUMPTIONS

1. Temperature of condensate return water is 140°F, boiler supply water is 75°F $\therefore \Delta T = 65°F$.
2. Loss of condensate return in plants is 600 GPD due to flooding/overflow.
3. Steam boiler efficiency = 70%.

CALCULATION

$$\frac{600 \text{ GPD} \times 8.33 \text{ \#/GAL.} \times 65°F}{.70 \text{ (EFF)}} = 464{,}100 \text{ BTUS/DAY}$$

BTU

Energy savings = 464,100 BTUS/DAY x 365 DAYS/YR. = 169 x 10^6 BTU/YR.

Energy savings ($) = 169 x 10^6 BTU/YR. x $1.18/$10^6$ BTU

Energy savings ($) = 200 $/YR.

Facilities personnel must clean up in Plant 1 after each overflow. The existing tank is set in the concrete floor.

APP. B-2

HVAC 6

ANNUAL ENERGY SAVINGS

Lock-out controls for heating coils.

AHUS 1, 6, 8, 12A, 13, 14A, 15A, 16, 25 & 26 (old numbers)

ASSUMPTIONS

1. Operation of units (use heating season) 8 HRS./DAY, 5 DAYS WK., 24 WKS./YR.
2. 10% loading of units (cooling in heating season).
3. KW/TON of refrigeration = 1.5.
4. Occurence of ambient temperatures above 68°F in typical 10 hr. operation during heating season = 20% (from weather data).
5. Motor efficiency 85% of rated power.

CALCULATIONS

$$\text{KW/TON} = \frac{\text{1.5 KW x .10 (loading)}}{\text{.85 (EFF)}} = 0.176$$

\$/TON/YR. = 8 HRS./DAY x 5 DAYS/WK. x 24 WKS./YR. x 20% x .176 KW/TON x \$.02/KW

\$/TON YR. = \$.84

$$\text{TONS} = \frac{\text{3345 MBTUH}}{\text{1200 \#/HR.}} = 279$$

Energy savings (\$) = 279 TONS x \$.84/TON/YR. = \$234/YR.

APP B-3

HVAC 7

ANNUAL ENERGY SAVINGS

Disconnect & remove Air Handling Unit 9 (old number). Use mechanical ventilation in room.

ASSUMPTIONS

1. Present operation of unit is 24 HRS./DAY, 7 DAYS/WK., 52 WKS./YR.
2. 50% loading of unit (average for year).) why?
3. Motor efficiencies 85% of rated power.
4. 1.5 KW/TON for running load (includes plant auxiliaries).
5. Electricity cost = $.02/KWH (includes demand charges).

SAVINGS CALCULATIONS

Plant Equipment

$$\text{KW/TON for running A/C system} = \frac{\text{Running Load of Equip.} \times \text{\% load}}{\text{Motor Efficiency}}$$

$$\text{KW/TON} = \frac{1.5 \text{ KW} \times .50 \text{ (load)}}{.85 \text{ (EFF)}} = .88$$

$/TON/YR. = HRS./DAY x DAYS/WK. x WKS./YR. x KW/TON x $/KWH

$/TON/YR. = 24 x 7 x 52 x .88 x .02 = $153.75/TON/YR.

$$\frac{92{,}000 \text{ BTU/HR. (coil capacity)}}{12{,}000 \text{ BTU/HR.}} = 7.7 \text{ TONS (coil capacity)}$$

Energy savings ($) = 7.7 TONS x $153.75/TON/YR. = $1,178/YR.

AHU Fan

No savings for fan because new ventilation fan will match energy consumption of existing AHU fan.

APP. B-4

HVAC 10 & 11

ANNUAL ENERGY SAVINGS

Replace steam boilers with hot water boilers of the same capacity in Plants 1 & 2. Cross connect Plants.

ASSUMPTIONS

1. Increased efficiency of equipment & reduction of heat transfer losses = 12%.

ENERGY SAVINGS

Boilers

1. Annual energy savings = 12% x 20.3 x 10^9 BTU
   = 2.4 x 10^9 BTU x $1.18/million BTU = $2,832/YR.

APP. B-5

ENERGY MONITORING & CONTROL SYSTEM

SUMMARY SHEET OF ENERGY SAVINGS

ITEM OR PROGRAM	ANNUAL SAVINGS
A. Air handling unit stop/start (comfort cooling spaces)	
1. AHU fan motors	$ 666
2. Plant cooling load	1,870
3. Plant heating load	695
B. Sequential cycling - AHU fan motors (comfort cooling spaces)	433
C. Sequential cycling AHU fan motors (equipment cooling spaces)	2,747
D. Hot & cold deck reset (2 AHUS)	
1. Cooling	273
2. Heating	170
	$6,854

APP B-6

EM 1

ANNUAL ENERGY SAVINGS - ELECTRICAL

I. START/STOP PROGRAM

A. Mornings & Evenings

Reduced running time of A/C equipment.

ASSUMPTIONS:

1. Two hours running time saved per day, 5 days/week 28 weeks/yr. (cooling season).

2. 50% load on equipment.

3. Motor efficiency 85% of rated power.

4. 1.5 KW/TON for running load (includes auxiliary equipment) for air conditioning system.

5. Electricity cost $.02/KWH (includes demand charges).

CALCULATIONS

KW/TON for air conditioning system =

$$\frac{\text{Running load of equipment} \times \text{\% load}}{\text{Motor efficiency}}$$

$$\text{KW/TON} = \frac{1.5 \text{ KW/TON} \times .50}{.85} = .88$$

SAVINGS

\$/TON/YR. = HRS./DAY x DAYS/WK. x WKS./YR. x KW/TON x \$/KW

\$/TON/YR. = 2 HRS./DAY x 5 DAYS/WK. x 28 WKS/ YR. x .88 KW/TON x \$.02/KW

\$/TON/YR. = \$4.90/TON/YR.

Energy savings (\$) = 4.9 x 379 TONS = \$1,870/YR.

APP B-7

EM 1

ANNUAL ENERGY SAVINGS - NATURAL GAS

Energy Monitoring & Control System

I. START/STOP PROGRAM

AHUS 1, 6, 8, 11, 12A, 13, 14A, 15A, 16, 25, 26, 27 (old numbers)
(comfort conditioned areas only)

ASSUMPTIONS

1. 2 hours running time saved per day, 5 DAYS/WK. 24 WKS./YR. (heating season).
2. Steam boiler efficiency = 70%.
3. 15% outside air on damper settings (average).
4. Gas cost = $1.18/million BTU.
5. Gas heating value = 1000 BTU/CF.
6. Assume $\triangle$ T 15°F (thermostat setting - O.S. air (DB))

CALCULATIONS

Basic Formula

BTUH = cfm x 1.08 x $\triangle$ T

Total cfm of AHUs = 97,910 O.A.? or unit.

BTUH = 97,910 x 1.08 x 15

TOTAL BTUH = 1,586,142

HRS./YR. = 2 x 5 x 24 = 260 HRS./YR.

TOTAL MBTU/YR. = 260 x 1,586 = 412,360

TOTAL CONSUMPTION MBTU/YR. = $\frac{412,360}{.70 \text{ (st. boiler EFF)}}$ = 589,000

Annual savings ($) = 589 million BTU/YR. x $1.18 = $695/YR.

APP B-8

EM 1

ANNUAL ENERGY SAVINGS - ELECTRICAL

A. Stop/Start

Air Handling Unit Motors (Comfort Cooling Spaces)

ASSUMPTIONS

1. Two hours running time saved per day, 5 DAYS/WK., 52 WKS./YR.
2. Load factor = .85% ?
3. Motor efficiency = 90%

CALCULATIONS

KW/HP = .746

$$\text{KW/HP actual} = \frac{.746 \times LF}{EFF} = \frac{.746\ (.85)}{.9} = 0.704$$

SAVINGS

\$/HP/YR. = 24 HRS./DAY x 5 DAYS/WK. x 52 WKS. x .704 KW/HP x .02 \$/KWH

\$/HP/YR. = 7.32

Energy savings (\$) = 91 (connected HP) x 7.32

Energy savings (\$) = \$666/YR.

EM 1

?

ANNUAL ENERGY SAVINGS

Reset Controls & Load Analyzers

AHU's 10 & 11 (old numbers)

AHU	CFM	Cooling MBTUH (CALC) 10°Δ T	Heating MBTUH (CALC) 20°Δ T	Type Air Distr.	Type of Load
10	6,070	304	150	Multi Zone Low Vel.	Comfort
11	13,700	958	500	Mix Box High Vel.	Comfort

ASSUMPTIONS

1. Operation of units is 8 HRS./DAY, 5 DAYS/WK./ 52 WKS./YR.
2. 50% loading of units.
3. 85% equipment efficiency (cooling).
4. 70% equipment efficiency (heating).
5. Savings - 15% of consumption.

CALCULATIONS

A. Cooling Equipment

Design capacity of coils = (304 + 958) MBTUH x 8 HRS./DAY x 5 DAYS/WK. x 52 WKS./YR. = 2,624,960 MBTUH/YR.

$$\text{Energy consumption} = \frac{2{,}624{,}960}{.85\ (\text{EFF})} \times .50\ (\text{loading}) = 1{,}544{,}094\ \text{MBTUH/YR.}$$

Energy savings = (0.15) x 1,544,094 MBTU/YR. = 231,614

Energy Savings ($) = (231.6 million BTU/YR.) x $1.18 million BTU

Energy Savings ($) = 273 $/YR.

APP. B-10

Calculations (cont'd.)

B. Heating Equipment

Design capacity of coils = (150 + 500) MBTUH x 8 HRS./DAY x 5 DAYS/WK. x 52 WKS./YR.

$$\frac{\text{Design capacity of coils}}{\text{Energy consumption}} = \frac{1,352,000}{.70\ (\text{EFF})} \times .50\ (\text{loading}) = 965,714\ \text{BTU/YR.}$$

Energy savings = .15 (965,714 MBTU/YR.) = 144,857 MBTU/YR.

Energy savings ($) = (144.9 million BTU/YR.) x $1.18 = $170/YR.

EM 1

ANNUAL ENERGY SAVINGS - ELECTRICAL

A. Sequential Load Cycling

Air Handling Unit Motors (comfort cooling spaces)

ASSUMPTIONS

1. Eight operating HRS./DAY, 5 DAYS/WK., 52 WKS./YR.
2. Cycle off 10 minutes each hour = 1 1/3 HRS./DAY.
3. KW/HP = .704 (see Calculation for Stop-Start Program)

CALCULATIONS

$/HP/YR. = 1 1/3 HRS. x 5 DAYS/WK. x 52 WKS./YR. x 0.704 KW/HP x .02 $/KWH

$/HP/YR. = $4.87

Energy savings ($) = 91 (connected HP) x $4.87/HP/YR.

Energy savings ($) = $433/YR.

B. Sequential Load Cycling

Air Handling Unit Motors (equipment cooling spaces)

ASSUMPTIONS

1. Twenty four operating HRS./DAY, 7 DAYS/WK., 52 WKS./YR.
2. Cycle off 10 minutes each hour = 4 HRS. DAY
3. KW/HP = .704 (see Calculation for Stop-Start Program)

CALCULATIONS

$/HP/YR. = 4 HRS./DAY x 7 DAYS/WK. x 52 WKS./YR. x 0.704 KW/HP x .02 $/KWH

$/HP/YR. = 20.5

Energy savings = $20.50/HP/YR. x 134 = $2,747/YR.